**ME 481 Introduction to Computer-Aided Analysis of Machine Dynamics, Spring 2022 – 316 Leonhard - 11:15-12:05 M W F**

Faculty: H.J. Sommer 301C Reber hjs1@psu.edu www.me.psu.edu/sommer/me481

Text: *Design of Machinery,* Norton, McGraw-Hill (optional reference)

Software: MATLAB, Working Model (WM), SolidWorks (SW)

Grading: homework=10 each, final project=50

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| Wk | Lect | Date | On-line notes | Topic | Homework due |
| 1 | 1 | Jan 10 | 01\_01 | administration, introduction |  |
|  | 2 | Jan 12 | 01\_01 | topology, mobility |  |
|  | 3 | Jan 14 | 02\_01,02\_02 | Working Model | H01 review |
| 2 | 4 | Jan 17 |  | no class – MLK Day |  |
|  | 5 | Jan 19 | 03\_01 | geometric kinematics  |  |
|  | 6 | Jan 21 | 03\_02 | complex number kinematics | H02 topology |
| 3 | 7 | Jan 24 | 03\_03 | Newton-Raphson solution |  |
|  | 8 | Jan 26 | 03\_04 | multiloop mechanisms |  |
|  | 9 | Jan 28 | 03\_05 | instantaneous centers | H03 WM kinematics |
| 4 | 10 | Jan 31 | 03\_05 | instantaneous centers |  |
|  | 11 | Feb 2 |  | no class |  |
|  | 12 | Feb 4 | 04\_01,04\_02 | 2D coordinate transformations | H04 Newton-Raphson |
| 5 | 13 | Feb 7 | 04\_03,04\_04 | 2D kinematics |  |
|  | 14 | Feb 9 | 04\_04,04\_05 | joint constraint kinematics |  |
|  | 15 | Feb 11 | 04\_04,04\_05 | joint constraint kinematics | H05 Wanzer |
| 6 | 16 | Feb 14 | 04\_06 | joint constraint kinematics |  |
|  | 17 | Feb 16 | 05\_01,05\_02 | experimental kinematics |  |
|  | 18 | Feb 18 | 02\_04 | SolidWorks Motion | H06 constraint kinematics |
| 7 | 19 | Feb 21 | 06\_01 | Newtonian mechanics for statics |  |
|  | 20 | Feb 23 | 06\_02,06\_03 | Newtonian mechanics for statics |  |
|  | 21 | Feb 25 | 06\_02,06\_03 | virtual work | H07 experimental kinematics |
| 8 | 22 | Feb 28 | 07\_01 | centroidal polar moment of inertia, radius of gyration |  |
|  | 23 | Mar 2 |  | no class | project prospectus |
|  | 24 | Mar 4 | 07\_02 | polygonal moment of inertia | H08 SW kinematics |
| 9 | 25 | Mar 14 | 07\_03 | experimental moment of inertia |  |
|  | 26 | Mar 16 | 07\_04 | vehicle inertial measurements | project proposal |
|  | 27 | Mar 18 | 08\_01 | forward versus inverse dynamics | H09 WM static, virtual work |
| 10 | 28 | Mar 21 | 08\_02 | classical inverse Newtonian dynamics |  |
|  | 29 | Mar 23 | 08\_03 | d'Alembert's Principle, virtual work |  |
|  | 30 | Mar 25 | 08\_04 | shaking force | H10 mass moment |
| 11 | 31 | Mar 28 | 08\_05 | multiplanar balancing |  |
|  | 32 | Mar 30 |  | no class |  |
|  | 33 | Apr 1 | 08\_06 | friction and damping in vibration | H11 shaking force |
| 12 | 34 | Apr 4 | 09\_02 | forward dynamics, Lagrangian dynamics |  |
|  | 35 | Apr 6 | 08\_11,08\_12 | differential algebraic equations (DAE) |  |
|  | 36 | Apr 8 | 10\_01 | state space models | H12 WM stick-slip |
| 13 | 37 | Apr 11 | 10\_02 | time integration |  |
|  | 38 | Apr 13 | 10\_02 | time integration |  |
|  | 39 | Apr 15 | 10\_03 | simulating DAE, friction, backlash | H13 frequency content |
| 14 | 40 | Apr 18 | 10\_04 | collision |  |
|  | 41 | Apr 20 | 10\_04 | collision |  |
|  | 42 | Apr 22 | 10\_04 | collision | H14 integration |
| 15 | 43 | Apr 25 | 01\_02, 11\_01 | intro to 3D |  |
|  | 44 | Apr 27 |  | no class |  |
|  | 45 | Apr 29 | 11\_02 | intro to 3D | H15 collision |
|  |  | May 4 |  | Pecha Kucha 15 slides x 20 sec timed presentations | send as email attachment |

**Course Objectives**

1) Recognize constrained kinematic chains embedded in larger engineering systems

2) Identify forward and inverse dynamic problems

3) Plan, implement and debug an appropriate computer-based design tool to analyze kinematics and dynamics of 2D constrained mechanisms

4) Use numerical integration methods and other numerical solution techniques

5) Learn and understand the underlying algorithms and theory behind commercially available mechanism analysis software

6) Communicate well using verbal, written and electronic methods

**Course Policy**

1) All students must attend class or view all posted video lectures.

2) Homework assignments must be **individual** work.

3) Students should know and understand these course policies in regard to College of Engineering policy on academic integrity available at [**http://www.engr.psu.edu/faculty-staff/academic-integrity.aspx**](http://www.engr.psu.edu/faculty-staff/academic-integrity.aspx).

**Homework Policy**

1) Homework is due by 11:59pm Eastern Time on dates assigned in the syllabus. No late submissions will be accepted unless prior approval has been granted.

2) Students should submit PDF copy for all homework via Canvas. **Combine all files into a single PDF.** Use filename convention "Lastname\_Hxx.pdf" where xx = 01, 02, 03, etc.

**Final Project Information**

Final project topics are your choice and may be drawn from your research/teaching interests, industrial experience, hobbies or intriguing devices. ***Be creative.*** Your mechanisms may be open loop or closed loop, static or dynamic. The projects may range from design of novel mechanisms, to analysis of existing devices, to exemplar use of analysis packages, to modeling of biological motion, to construction of working prototypes (passive, motorized or instrumented).

The intent of this project is to provide some personal insight into kinematics and dynamics outside the content of the class. It is not intended as a burdensome requirement, rather as an opportunity for you to gain some practical experience on a topic of your choice. You may work with a partner on this project.

### Final Project Deliverables

1) A brief three sentence prospectus for your project concept

2) A short, one page proposal detailing your project concept and project team. The proposal should contain WHO comprises your project team, WHAT you wish to accomplish, WHY this topic is pertinent or interesting or valuable, and HOW you plan to complete this project (e.g. time plan, requisite resources)

3) A five minute PPTX with voice-over

 a) modified Pecha Kucha format, 15 slides by 20 seconds each, automatically timed

 b) maximum size able to send by email attachment

 c) filename convention = lastname\_partnerlastname.PPTX

**Notice of Video Recording**

Video and audio recordings of class lectures will be part of the classroom activity. The video and audio recording is used for educational use/purposes and may be made available to all students presently enrolled in the class. For purposes where the recordings will be used in future class session/lectures, the videos will adequately remove any type of student identifying information.

**World Campus technical support** wdtechsupport@outreach.psu.edu

**Academic Integrity -** [**http://www.engr.psu.edu/faculty-staff/academic-integrity.aspx**](http://www.engr.psu.edu/faculty-staff/academic-integrity.aspx)

The University defines academic integrity as the pursuit of scholarly activity in an open, honest and responsible manner. All students should act with personal integrity, respect other students' dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts (refer to [Senate Policy 49-20](http://senate.psu.edu/policies-and-rules-for-undergraduate-students/47-00-48-00-and-49-00-grades/#49-20). Dishonesty of any kind will not be tolerated in this course. Dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. Students who are found to be dishonest will receive academic sanctions and will be reported to the University's Office of Student Conduct for possible further disciplinary sanctions (refer to [Senate Policy G-9](http://undergrad.psu.edu/aappm/G-9-academic-integrity.html)).

**Disability -** [**http://equity.psu.edu/ods/faculty-handbook/syllabus-statement**](http://equity.psu.edu/ods/faculty-handbook/syllabus-statement)

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. The Office for Disability Services (ODS) Web site provides contact information for every Penn State campus: <http://equity.psu.edu/ods/dcl> . For further information, please visit the Office for Disability Services Web site: <http://equity.psu.edu/ods> .

In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: <http://equity.psu.edu/ods/doc-guidelines> . If the documentation supports your request for reasonable accommodations, your campus’s disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early in your courses as possible. You must follow this process for every semester that you request accommodations.

**Counseling & Psychological Services (CAPS)**

CAPS can help students resolve personal concerns that may interfere with their academic progress, social development, and satisfaction at Penn State. Some of the more common concerns include anxiety, depression, difficulties in relationships (friends, roommates, or family); sexual identity; lack of motivation or difficulty relaxing, concentrating or studying; eating disorders; sexual assault and sexual abuse recovery; and uncertainties about personal values and beliefs.

You can contact CAPS by calling the Main CAPS number/Appointment Scheduling: 814-863-0395 (Please call between the hours of 8am and 5pm, Monday-Friday to schedule an appointment) or visit us at our office location, 5th Floor Student Health Center.